

Overview of Essential Nutrients

Nitrogen, phosphorus, and potassium are often referred to as the primary macronutrients, because of the general probability of plants being deficient in these nutrients and the large quantities taken up from the soil compared to other essential nutrients.

Nitrogen

Of all the essential nutrients, nitrogen (N) is the one most often limiting for plant growth. Many soils contain large amounts of nitrogen, but most of it is tied up in the organic fraction of the soil and only slowly released.

Nitrogen is available to plants in two forms, ammonium and nitrate. In most soils, ammonium is quickly converted to nitrate. Nitrate is not held on soil particles and is easily dissolved in water. Thus it is susceptible to leaching. Therefore the timing and rates of nitrogen fertilization are important from both a plant growth and environmental standpoint. On sandy soils, nitrogen applied early in the season can be easily leached out of the root zone with heavy rainfall or irrigation. Nitrogen deficiency may result, as well as an increased potential for nitrate contamination of groundwater. Nitrogen fertilizer should be applied in a series of smaller applications on sandy soils.

Because of the mobility of nitrate in soils and the complex transformations of nitrogen from soil organic matter, soil tests for nitrogen are not reliable for predicting nitrogen fertilizer needs in many situations. Nitrogen fertilizer recommendations in this bulletin are based on the kinds of plants being grown and the organic matter content of the soil. Nitrogen recommendations are reduced as the organic matter level increases. The classifications used for organic matter are:

low - organic matter less than 3.1%

medium - organic matter 3.1–4.5%

high - organic matter 4.6%–19%.

Organic soils are classified as those soils with an organic matter content greater than 19%.

Phosphorus

Phosphorus (P) forms very insoluble (hard to dissolve) complexes with aluminum and iron at low pH and with calcium at high pH. Consequently, movement of phosphorus in soils is very low. For this reason, it is important to incorporate phosphate fertilizer into the soil rather than apply it as a topdressing.

Phosphorus is the main nutrient associated with algal blooms in lakes. Phosphorus can enter lakes by runoff and wind erosion of soil particles as well as runoff of organic phosphorus from decaying leaves, seeds or grass clippings that are left on streets, driveways, and other hard surfaces.

Research has shown that excessive applications of phosphorus fertilizer on high testing soils can result in significant water degradation if it leaves the site via runoff. Because many lawns in Minnesota test very high in P, the Minnesota legislature passed a state-wide law that restricts the application of P fertilizer to established turf. A brief summary of the law is as follows. Lawn fertilizer use is restricted to 0% phosphate (P_2O_5) content. Exceptions include 1) if a new lawn is being seeded or sodded and only during the first year of establishment, 2) if a soil or tissue test shows a need for P, or 3) if the fertilizer is used on a golf course by a person certified by an approved training program. In those cases, lawn fertilizers with P can be used. More detail pertaining to the law can be found in Chapter 18C.60 of Minnesota Statutes (<http://www.revisor.leg.state.mn.us/stats/18C/>). Because of this law, soil testing becomes even more important for managing applications of phosphorus to turf. Refer to the lawn and turf section of this bulletin where P recommendations for established turf are presented in **Table 15**.

Phosphorus fertilizer recommendations are based on the kinds of plants being grown and the phosphorus soil test level. Two different soil tests are used to determine available soil phosphorus. The Bray-P1 test is used when the soil pH is 7.4 or less and the Olsen-P test is used when the soil pH is greater than 7.4. It is important to note that interpretations for phosphorus fertilizer will change, depending on which test is used.

In other words, the amount of extractable phosphorus using the Bray-P1 test is not equivalent to the amount of extractable phosphorus using the Olsen-P test. Relative levels of phosphorus based on each soil test are presented in **Table 6**.

Table 6. Relative levels of Bray and Olsen soil test phosphorus

Relative level	Bray-P1	Olsen-P
	Soil test P	
	ppm	ppm
low	0 - 5	0 - 3
medium	6 - 10	4 - 7
high	11 - 25	8 - 18
very high	over 25	over 18

Potassium

Movement of potassium (K) in soils depends on soil texture. As clay content increases, potassium movement decreases. For most soils, it is important that applied potassium be incorporated into the soil rather than topdressed because it is relatively immobile. In sandy soils, potassium is quite mobile and can actually leach out of the root zone. Consequently, sandy soils tend to be low in available potassium. Potassium fertilizer

Table 7. Relative levels of soil test potassium

Relative level	Soil test K
	<u>ppm</u>
low	0 - 50
medium	51 - 100
high	101 - 150
very high	over 150

recommendations are based on the kinds of plants being grown and the potassium soil test level. Relative levels of potassium based on the potassium soil test are presented in **Table 7**.

Secondary Macronutrients

Calcium, magnesium, and sulfur are taken up in relatively large amounts by plants and are termed the secondary macronutrients. Because most soils in Minnesota contain adequate amounts of these nutrients, they are not generally limiting to plant growth. Deficiencies of these nutrients may occur on acid sandy soils that are low in organic matter. Soil tests are available for these elements, but they are recommended only under certain conditions where a deficiency might be expected to occur. This publication gives recommendations for secondary macronutrients only for intensively grown turfgrass areas such as golf courses and sod farms.

Micronutrients

Micronutrients, which include boron, chlorine, copper, iron, manganese, molybdenum, nickel, and zinc, are required in lower amounts than other essential nutrients. Soils in Minnesota generally contain sufficient quantities of micronutrients to meet plant needs, although deficiencies can occur under some conditions. This bulletin gives soil testing and fertilizer recommendations for micronutrients only for intensively grown turfgrass areas such as golf courses and sod farms. Copper can be limiting on some organic soils. High pH (greater than 7.2) can limit availability of iron, manganese, and zinc. Using composted yard waste and manure in gardens will help to supply micronutrients.